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ABSTRACT

This report concerns the effects of prequestion and postquestion formats in prose learning in computer-assisted instruction. Five experimental groups studied a set of eight passages under different prequestion-postquestion combinations. Twenty-five subjects, volunteers with high school degrees, were randomly assigned to each group. A final retention test had 32 items classified along two dimensions: one dependant on whether the inserted text questions prompted attention to the item, and the other dependant on whether the item required factual or inferential learning. The CAI format facilitated control over exposure to questions and passages, as well as data collection on performance measures like referral to passages, time spent on inserted questions, total study time, and scores on postquestion sets. A combination of prequestions and postquestions led to a 20% increase in student study time relative to the use of either question format alone, but did not facilitate relevant retention beyond the facilitation found with just prequestions or just postquestions. The use of prequestions interfered with incidental learning. While equal to the prequestions format in study time and effect on relevant learning, the postquestions format seemed preferable since it was not accompanied by depressed incidental learning. (Author)

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Technical Report No. 4

The Effects of Pre- and Postquestions on Learning from Textual Material in a CAI Format

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January 1977

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20. ABSTRACT continued

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The Effects of Pre- and Postquestions or Learning from Textual Material in a CAI Format

INTRODUCTION

The study described in this report explores the use of questions to help students learn from instructional materials presented on a computer terminal. In particular, three ways of questioning students about the materials they are studying are compared. One questioning format presents questions before a student sees the text itself. In this format the student may also review these questions while he studies the text. A second questioning format displays questions only after the student has completed studying the text. In this format the student is not allowed to review the text when he has reached its questions. The final questioning scheme combines both these formats: questions are displayed before the text and whenever the student wishes to review them; after the student completes his study of the text questions are presented again.

Numerous investigations have been concerned with the effects of questions available during or after study. The research reported here extends these efforts by considering the effects of using questions both during and after the study of textual materials.

After a brief review of relevant research on the use of questions as aids to textual learning, the details and results of our investigation will be presented.

REVIEW OF RESEARCH

Providing students with questions has been shown to enhance learning from textual materials (Boyd, 1973; Rickards & Di Vesta, 1974). Not only is retention of information relevant to the questions facilitated by their use, but questions may also facilitate retention of passage information that does not answer inserted questions (Bruning, 1968; Rothkopf & Bisbiscos, 1967). Rothkopf (1966, 1972) has attributed the effects of questions to the control which they exert over the learner's inspection and processing of the materials. The position of questions relative to the text is critical to the type of control which is exerted.

Questions read before related text segments direct the student's attention to specific portions of the text (Frase, 1970), namely those portions from which answers to the questions can be derived. As might be expected, readers using such prequestions generally demonstrate greater learning of question-relevant information than do those studying without access to questions. But this positive increase is frequently accompanied by a relative decrease in the learning of information outside the scope of the prequestions. Anderson and Biddle (1975) reviewed 18 studies on the use of prequestions and incidental learning; they found a depressed level of incidental learning reported in 13 of the studies. Thus it appears that prequestions induce more attention to selected text segments than would normally be given but may also lead to a reduction in the attention given to the remaining segments.

The effects of prequestions, especially on incidental learning, may be a function of the learner's understanding of the role of prequestions relative to the goal of instruction (Duchastel & Brown, 1974). If the learner believes the goal of instruction is to learn information pertaining to the prequestions, his reading is apt to focus strongly on relevant information at the expense of incidental information; if the reader believes the goal of instruction is to learn both incidental and relevant information, his reading is apt to be less selective. The directions given students concerning the purpose of prequestions relative to the purpose of instruction have varied considerably across studies. The majority of investigators have associated the two only weakly, if at all. In view of this variation it is surprising that so much evidence confirms the conclusion that prequestions depress incidental learning. As might be expected, however, the effect has often been small. In those 13 studies found by Anderson and Biddle (1975) in which incidental learning was depressed, the mean % decrement in scores was only 2.8.

Questions which follow textual materials effect the learner's reading behavior differently than do questions which precede materials. Since postquestions are seen after the textual materials have been completed, the materials are not studied with the selective attention found with prequestions. Unlike prequestions, postquestions typically facilitate question-relevant retention without any accompanying depression in question-incidental retention (Rothkopf, 1966). Indeed some researchers have found that students given postquestions retain more incidental information than do those not given post-questions (Rickards & Di Vesta, 1974; Rothkopf & Bisbiscos, 1967).

The effects of postquestions on question relevant information can be attributed to the reader's recall and review of information retained in memory that pertains to the questions (Anderson and Biddle, 1975). In fact, the recall and review resulting from post-questions may also involve information incidental but topically related to the question-relevant information; McGaw and Grotelueschen (1972) and Rothkopf and Billington (1974) found that postquestions enhanced both question-relevant information and information only topically related to the relevant information.

Interest in research exploring the effects of postquestions on question-relevant information has been overshadowed by research exploring the effects of postquestions on incidental information. The latter research has been stimulated by a number of reports that readers receiving postquestions show superior incidental learning relative to read-only control students (e.g., Bruning, 1968; Rothkopf, 1966; Rothkopf & Bisbiscos, 1967).

These indirect effects of postquestions have been shown to be dependent on both the type of learning required to answer the question and the frequency with which questions occur within the text. For example, Falker and Dapra (1975) explored the

possibility that answering verbatim rather than comprehension post-questions could differentially affect students' ability to apply principles and concepts discussed in the text. The verbatim post-questions required recognition of exact text wording while the comprehension questions required understanding of the semantic meaning of text wording. Both question types were matched in content and focus. On the problem solving test which followed study of the text materials, the group using comprehension postquestions outperformed the group using verbatim questions. In fact the group with verbatim questions performed no better than the read-only control group.

Rickards and Di Vesta (1974) varied both the type of learning required to answer the questions and the frequency with which postquestions appeared. These investigators used three types of postquestions: one type required literal verbatim recall of facts, another required literal verbatim recall of ideas, while the third required recall and organization of facts supporting ideas. Students encountered a postquestion either after every second paragraph of text, or after every fourth paragraph of text. When questions appeared more frequently, both literal verbatim recall of ideas and recall and organization of facts supporting ideas were found to result in significantly more learning of incidental ideas than literal verbatim recall of facts. Furthermore, recall and organization of facts supporting ideas resulted in significantly more learning of incidental facts than the other two activities. But, when questions were asked less frequently, incidental retention was the same in all groups.

One explanation for the indirect effects of postquestions is given in terms of shaping (Rothkopf, 1972). According to this explanation, a student's reading behaviors preceding those postquestions which he can answer are reinforced and maintained, while those preceding questions which cannot be answered are not

reinforced and become altered. What may result then is that the reader responding to postquestions will attend more than he normally would to that type of information to which postquestions are likely to refer. Hence, if the incidental items on the criterion test are representative of the postquestions, the reader who received postquestions is more likely to have retained the information they require.

With this explanation, a parallel emerges between the effects of pre- and postquestions: where prequestions may focus the reader's attention on those text stimuli which provide answers to the prequestions, postquestions may focus his attention on classes of text stimuli which are likely targets for future postquestions. It can be argued though that the reader's intention is related to the former effect, while it may not be related to the latter (Rothkopf, 1972); whereas the student using prequestions chooses to focus his attention, the student using postquestions may not be aware of his selective attention.

Other explanations for the indirect affects associated with postquestions have been advanced, including the idea that post-questions provide practice for taking the criterion test. Indeed, the results of Felker and Dapra (1975) indicate that when the demands of the postquestions parallel those of the criterion test, incidental learning will be facilitated.

In their review of the effects of questions on reading, Anderson and Biddle (1975) conclude that postquestions produce greater learning than do prequestions. As might be inferred from what has been said above, postquestions have almost consistently been shown to result in better performance on incidental learning than do prequestions. But also on relevant learning where both

question formats have been shown to have positive results, there is a trend for the effects of postquestions to be stronger and more consistent than those of prequestions.

The finding that postquestions are superior to prequestions in relevant retention is unexpected when one compares the memory requirements involved in answering the questions. As Rickards (1976) has noted, in the typical study investigating the effects of pre- and postquestions, the use of prequestions involves considerably less reliance on memory than does the use of postquestions. Students are typically not allowed to review the text after they have reached its postquestions. To correctly answer a postquestion then, a reader is required to remember one or perhaps several items of information from a text containing many other items of information which have competed for his attention. To answer a prequestion the reader has the text at his disposal; furthermore, his attention, can focus on that information relevant to the question. The option of reviewing the prequestions while reading the text has varied from study to study, but even if the reader is not given the option of looking back at the prequestions, the memory requirement imposed may be considerably less than is called for in the postquestion format. Hence, it would seem that the probability of learning question-relevant information is higher when prequestions are used than when postquestions are used.

That postquestioning is in fact superior to prequestioning in relevant retention suggests that the study behaviors resulting from postquestions result in more effective learning of the question-relevant information than do those resulting from prequestions. Whereas the student may more often successfully formulate an answer to a prequestion than a postquestion, what is learned by those using postquestions is retained more effectively. Apparently, the advantage prequestions have in terms of memory requirements does not compensate for the relatively less effective study behaviors which they induce.

A natural extension to the investigation of pre- and post-questioning is the exploration of the effects on studying when the two are combined in one treatment. With respect to the retention of relevant information, does the study behavior invoked by the combination prove superior to those behaviors associated with either format alone? And what will be the effects of a combined format on the retention of incidental information?

Strongly supported answers to these questions are not available as little research has been conducted which explores the combined questioning format. Boyd (1973) reports one of the few studies which compared the combination with either format alone. Based on Boyd's results and what is known about the effects of postquestioning and prequestioning, some expectations about the combined format will be advanced.

Boyd found that those given both pre- and postquestions performed significantly better on the retention of question-relevant information than did those using only prequestions. The addition of postquestions to prequestions adds to the reading behavior typically resulting from prequestions further processing of question-relevant information. It is expected that this additional processing will result in less forgetting of that relevant information. Hence, with respect to the retention of relevant information, the study behavior invoked by the combination should prove superior to that which results from prequestions alone.

Boyd also found that those given both pre- and postquestions performed significantly better on the retention of question-relevant information than did those using only postquestions. As has been mentioned before, the reading behaviors induced by prequestions may result in less effective learning of question-relevant information than do those which are induced by postquestions. Indeed, Boyd's data does indicate that those groups given only postquestions did

tend to perform better on relevant retention than did those groups given only prequestions. Apparently the addition of postquestioning to prequestioning may compensate for this relatively less effective learning and result in a questioning format that is superior to postquestioning alone.

In Boyd's study incidental learning was depressed to the same degree in both the groups receiving only prequestions and those receiving both pre- and postquestions. As we have mentioned before, prequestions do tend to focus the student's attention on question-relevant information. Apparently the addition of postquestions to prequestions does little to alter this focusing. The effects of a combined format on incidental learning will be similar to those of prequestioning alone.

The primary purpose of our study was to provide more information concerning the effects of inserting questions both before and after the text. The questions used by Boyd were one-word completions requiring verbatim recall. The questions used in our study were multiple choice typically requiring a higher level of reader comprehension than is required by verbatim recall. Whether Boyd's results would be replicated with different types of questions was a central concern of our investigation.

A secondary objective of our study was to pursue this investigation within the context of computer-assisted instruction and thus extend the range of materials to which results might apply. In computer-assisted instruction the presentation of text is a common instructional event. It was hoped that this research would provide authors of computer-assisted instruction programs with guidelines concerning optimum questioning formats to use when textual materials are to be presented.

METHOD

Experiment Participants. One hundred and twenty-five undergraduates from a local four year college participated in the study. The students were paid volunteers solicited through classroom announcements and advertisements in the campus paper.

Each student studied a sequence of eight unrelated passages, using one of five different question formats. After studying the passages, students were requested to take a 32 item multiple choice retention test, with four questions relating to each passage.

Materials. The eight passages were selected from those used in the reading comprehension subtest of the Scholastic Aptitude Test (SAT). The passages chosen had been published in brochures describing the test and were no longer being used on forms of the SAT. They each averaged about 400 words in length. The topics covered by the passages were diverse, with four passages discussing topics in the physical and biological sciences, and four discussing topics in the social sciences and humanities. This range in topics was intended to facilitate implications for prose learning in general rather than for a specific subject matter.

Questions from the SAT associated with the passages provided about 60% of the questions required in the study. The remaining questions were constructed by the investigators in consultation with professional examiners whose full-time responsibility was test development. All questions were multiple choice in format.

The questions required five types of textual processing:

(1) comprehension of a supporting idea, explicitly stated in the passage,

(2) comprehension of a major idea only indirectly expressed in the passage,

(3) completion of an inference made in the passage,

(4) application of a generalization found in the passage to a particular instance,

and (5) evaluation of the logic of the author's discussion.

Questions of the first type were classified as lower order items. Questions of the remaining four types were labeled higher order items. The majority of the higher order items were of types 2 and 3. A total of 64 questions were used, four lower and four higher order items for each passage.

A better understanding of the question types can be gained through some examples. The following question based on a passage about the life-style of birds assesses comprehension of a supporting idea explicitly stated in the passage (type 1):

> It is essential that birds have an efficient respiratory system because they
>
> (A) are generally small in size
>
> (B) fly in rarefied atmsophere
>
> (C) have great muscular development
>
> (D) must be mentally alert to insure survival
>
> *(E) lead an active existence

The passage segment from which the question was derived reads:

> Respiration is efficient and indeed must be to sustain the high metabolic activity.

This particular item paraphrases the idea as explicitly stated. Both questions using paraphrased restatements and verbatim statements were actually used as lower-order items.

An example of an item assessing comprehension of a main idea (type 2) is taken from a passage which critically reviews Plato's Republic. Although the actual purpose of the work is not stated, the author provides enough information about its contents and the

manner in which it is written to allow the following question to be answered:

> It is inferred that Plato's Republic is a work written principally for the purpose of
>
> (A) providing citizens with a guide to the best possible life
>
> (B) changing existing methods of education
>
> *(C) convincing readers that the rule of the few is preferable to the rule of the many
>
> (D) convincing the populace of biological differences among classes
>
> (E) encouraging people to overthrow existing governments

In a passage concerning the development of anesthetics, the following statement is made:

> "Curare and its derivatives are being replaced by a number of synthetics that are more specific in action and predictable in effect."

Completion of an inference made in the statement is required by the following type 3 question:

> It can be inferred that a disadvantage of using curare derivatives as anesthetic agents is that they
>
> (A) are dangerously explosive
>
> (B) are difficult to manufacture
>
> *(C) can produce unexpected effects
>
> (D) are not as powerful as newer drugs
>
> (E) cannot be combined with other drugs

A passage concerning the evolution and operation of cooperatives makes the statement:

> A consumers' cooperative sells its goods at the prevailing competitive prices in order to avoid conflict with other retailers.

Application of the rule suggested in this statement concerning how a cooperative's prices are determined is required in the following type 4 question:

> Which of the following actions would probably be taken by a cooperative in response to a competitive price cut by neighboring stores?
>
> (A) It would maintain its prices and its dividend at their regular levels.
>
> (B) It would maintain its prices at their regular level and increase its dividend.
>
> *(C) It would cut its prices to equal those of its competitors.
>
> (D) It would cut its prices to undersell its competitors.
>
> (E) It would dissolve.

An example of the last item type comes from an historical passage concerning Puerto Rican politics. In the passage the author uses the term "unstable marriage." The meaning of the term can be determined by comprehending implications of statements which surround it. The following question assesses whether the reader has understood these implications:

> The author probably describes the Alianza as an "unstable marriage" in order to indicate that
>
> (A) it had not been officially sanctioned by the government
>
> (B) one faction was deliberately undermining the united party
>
> (C) one group had been misinformed about the party's platform
>
> (D) there had not been unanimous consent to the coalition
>
> *(E) it included two irreconcilable factions

Each passage had four higher-order and four lower-order questions associated with it. The higher- and lower-order questions for a passage were randomly paired, and the pairs randomly assigned a number from 1 to 4. The item pairs were then assigned as inserted prequestions, inserted postquestions, and/or retention test items on the basis of the numbers they received. Table 1 summarizes the assignment scheme of a passage set of item pairs relative to the five format groups.

Table 1

Question Assignment Relative
to Format Groups

Format	Assignments		
	Prequestions	Postquestions	Retention Items
CONTROL	none	none	1,2
PRE	1,3	none	1,2
POST	none	1,3	1,2
PRE/POST(R)	1,3	1,3	1,2
PRE/POST (P)	1,3	3,4	1,2

Note. Numbers refer to item pair assignments.

The following remarks can all be inferred from Table 1; they concern the questions seen by the various groups on a given passage. Question pairs 1 and 2 were used to measure retention for all five groups. For all groups except CONTROL, question pair 1 measured relevant learning, and question pair 2 measured incidental learning. Question pairs 1 and 3 were seen by all groups except CONTROL: as prequestions by group PRE, as postquestions by group POST, and as both pre- and postquestions by group PRE/POST(R). The group PRE/POST(P) saw question pairs 1 and 3 as prequestions, but only pair 3 was repeated in the postquestioning; they saw the final question pair, 4, for their remaining two postquestions. Thus, none of this group's postquestions were repeated on the retention test.

Those stems of questions used as both pre- and postquestions were revised so that the item could be stated as an open-ended question requiring the student to formulate his own response. This was the form in which prequestions were presented, while postquestions were

presented in multiple choice format. For example, of the questions given as illustrations of the types of questions used in the study, 4 were selected for use as both prequestions and postquestions. As postquestions they appeared in the multiple choice format presented above; as prequestions they appeared as follows:

> According to the passage, why is it essential that birds have an efficient respiratory system?
>
> What disadvantage of using curare derivatives as anesthetic agents may be inferred from the passage?
>
> It may be inferred from the passage that a cooperative's response to a competitive price cut by neighboring stores would be ...?
>
> What is the author probably implying with the use of "unstable marriage" to describe the Alianza?

The passages were placed into the topical groupings of physical/biological sciences and social sciences/humanities. Item analysis data from previous test administrations was available for those passage items borrowed from the SAT. The data was used to order the passages in each topical set in terms of the difficulty of their associated questions, the passage with easiest questions coming first. This method of passage ordering was chosen because it was felt that presenting progressively more challenging questions was typical of instructional materials. Two passage presentation orders were used in the study; both orders maintained the topical grouping orders. One presentation order placed all the social science/humanities passages first, followed by the physical/biological science passages, while the second alternated between the two topical groups, with the easiest social science/humanities passage first.

All passages and inserted questions were presented to the students via a PLATO computer terminal. The retention test was in paper and pencil format. The computer presented the study materials as follows: all prequestions for a passage were contained on one display, separate from the passage; the passages were contained on one or two displays, depending on their length; each postquestion appeared on a separate display.

Through the use of selected keys on the terminal keyboard, students controlled the rate at which materials were presented.

Those having access to prequestions were presented the display of a passage's prequestions prior to the presentation of the passage. While they studied the passage, those using prequestions were free to review them as often as desired. Students were not required to overtly respond to prequestions. Those having access to postquestions were not allowed to review the passage after they had requested the display of its postquestions. Those using postquestions were required to answer the postquestions by pressing the terminal key designating their alternative choice (a,b,c,d, or e). Students were not allowed to review a postquestion once they had seen it and had gone on to another display.

Question Formats. Five question formats were explored. They will be denoted CONTROL, PRE, POST, PRE/POST(R), and PRE/POST(P).

CONTROL: Those using the CONTROL format saw no inserted questions during their study of the passages.

PRE: Students studying the passages using the PRE format received prequestions before each passage. Four prequestions preceded each passage, two higher order and two lower order. The prequestions were open-ended requiring the student to formulate his own response.

POST: Students studying the passage using the POST format received postquestions after each passage. Four questions followed each passage. These were the same questions that those using the PRE format saw before each passage, but were stated as multiple choice rather than open-ended questions.

PRE/POST(R): Students studying the passage using this format received both the prequestions received by the PRE students and the postquestions received by the POST students. The 'R' in the above name denotes the fact that the postquestions repeated the prequestions, i.e., there was a one-to-one correspondence between the open-ended prequestions and the multiple choice postquestions.

Half of those questions seen by the student groups described above also appeared on the retention test, 2 from each passage, 1 higher

order and 1 lower order. Those questions repeated on the retention test appeared in the multiple choice form.

The PRE group dealt only with the open-ended forms of the inserted questions repeated on the retention test. Because of this, if we found that the PRE/POST(R) group outperformed the PRE group, some of that improvement could be attributed to the former group's practice with criterion-like items. To separate out the effects of criterion test practice provided by the postquestions from the effects of further relevant information processing resulting from the postquestions in the PRE/POST(R) format, the following format was included in the study.

> PRE/POST(P): For each passage, students studying the materials using this format received the prequestion set used by the PRE and PRE/POST(R) groups, but received only two of the postquestions seen by the POST and PRE/POST(R) groups. The two postquestions presented were those lower order and higher order items <u>not</u> repeated on the retention test. In addition, two more questions were added to the each postquestion set, 1 higher order and lower order, that were not used by any of the other groups and not included on the retention test. (This accounts then for the 16 items whose function was not identified above.)

Thus those in the PRE/POST(P) group did not receive as postquestions any of the items which later appeared on the retention test. The 'P' in the above name denotes the fact that the postquestions provided only practice.

The PRE/POST(P) group allowed us to explore, not only the effects of practice, but also the effects on reading behavior of postquestions referring to prequestion-incidental information. It was expected that prequestions alone would cause students to focus their attention on the prequestioned information to such an extent that the learning of incidental information would be impaired. If postquestions repeating the prequestions were added (i.e., the PRE/POST(R) format),

the focusing would not be altered. But, if the postquestion set included new questions, would the student not only search for prequestion answers, but also prepare for the new questions by studying more carefully other parts of the text? The investigators did expect that those in the PRE/POST(P) group would indeed attend more to prequestion-incidental information that did those in the PRE or PRE/POST(R) groups.

Procedures. A PLATO terminal was installed on the campus of the local college. Student participants were signed-up for individual appointments of approximately 90 minutes. They were randomly assigned to a question format. Twenty-five students were included in each group.

When a student arrived for his appointment, he was seated in front of the terminal and asked to read some directions. The directions discussed the purpose of the experiment and the use of the terminal. They also described the question format that the student would be using while he studied the passages. The directions read by the PRE and PRE/POST(P) groups are included in the appendix of this report. An attempt was made to maintain parallel, if not identical, directions for each group.

The directions for those students not using the CONTROL format indicated that, after their study of the materials, they would be given a test, and on that test would be the questions they had seen as inserted questions. There was no indication given of new questions appearing on the final test. In order to confirm that students did not expect new questions to appear on the retention test, a number of participants were asked, after they had completed the retention test, if they had expected new questions to appear on the test. All confirmed that they had not expected new questions.

The directions for CONTROL students specified that they should learn as much as they could from the passages. They were warned that

a test would follow their study, and on that test would be questions asking them to recall facts and ideas stated in the passages and make inferences based on things that had been said in the passages.

After a student completed the directions the principal investigator showed him how to use the keys he would need to work through the materials. Also, under the guidance of the investigator, the student practiced the key presses on a sample passage which included those inserted questions appropriate to the format to which the student was assigned.

All students were given as much time as they needed to complete the materials. But, once they had left a passage to go on to the next passage, they were not allowed to return to it. To provide some motivation for studying the materials, students were told that if they answered more than 40% of the retention test questions correctly, they would receive an extra monetary compensation for their participation in the study. In reality all students received the same reimbursement.

RESULTS AND DISCUSSION

Table 1 presents group means and standard deviations for the retention test subscores derived from the following sets of items: the eight higher order items that also appeared as inserted questions (higher order relevant learning-HRL), the eight lower order items that also appeared as inserted questions (lower order relevant learning-LRL), the eight higher order items that did not appear as inserted questions (higher order incidental learning-HIL), and the eight lower order items that did not appear as inserted questions (lower order incidental learning-LIL). Also included in the table are the means and standard deviations for total relevant retention (HRL + LRL), total incidental retention (HIL + LIL), and total overall retention (HRL + LRL + HIL + LIL). The data suggest that, with respect to relevant learning, the POST group outperformed those groups given prequestions. Furthermore, scores on the higher order questions account for most of

the relevant learning difference between the POST group and those groups who received prequestions. An unanticipated outcome in the data was the poor performance of the PRE/POST with practice group in incidental learning. The expectation that this group would outperform both the PRE group and the PRE/POST with repetition group in incidental learning was not supported. A more systematic analysis of the retention test scores will begin with some orthogonal contrasts.

Table 1

Results on Retention Test: Subscores and Total Score

TREATMENT	RELEVANT LEARNING						INCIDENTAL LEARNING						OVERALL	
	HRL(8)*		LRL(8)		TOTAL(16)		HIL(8)		LIL(8)		TOTAL(16)		TOTAL(32)	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
POST	6.04	1.27	6.32	.94	12.36	1.80	4.36	1.66	5.32	1.34	9.68	2.34	22.04	3.66
PRE	5.36	1.85	6.20	1.53	11.56	3.00	3.56	1.83	5.12	1.59	8.68	2.85	20.24	5.52
PRE/POST(R)	5.28	2.17	6.04	1.67	11.32	3.35	3.72	1.62	4.44	1.83	8.16	2.97	19.48	5.63
PRE/POST(P)	5.20	1.98	5.76	1.62	10.96	3.03	3.28	1.84	4.68	1.77	7.96	3.14	18.92	5.65
CONTROL	4.96	2.01	5.12	1.54	10.08	3.07	4.24	1.83	5.12	1.51	9.36	2.77	19.44	5.12

*Number in parentheses represents the maximum score possible

Orthogonal Contrasts for Relevant and Incidental Learning

Through orthogonal contrasts an attempt was made to answer the following questions concerning the retention of question-relevant information:

(1) How does the performance of students with access to questions compare with that of students without access to questions?

(2) How does the performance of students given only postquestions compare with that of students given prequestions?

(3) How does the performance of students given postquestions as well as prequestions, either in the form of practice or repetition, compare with the performance of those given only prequestions?

(4) When both pre- and postquestions are used, how do students given postquestions providing repetition *differ in performance from those given postquestions* providing practice?

The contrasts underlying these questions reflect some of our initial expectations about relative group performance in relevant retention. The first contrast allows us to determine whether access to questions facilitated the retention of question-relevant information. Based on the findings of other investigators, we expected that questioning would prove helpful. As was discussed in the review of research, postquestioning has typically been superior to prequestioning in facilitating relevant retention; by comparing the retention of those who received only postquestioning with those who received prequestioning with or without postquestioning, the second contrast allows us to access whether the superiority of postquestioning is supported by our data. The third contrast permits the comparison of the combined formats with prequestioning alone. Since we expected the combined formats to add to those behaviors typically resulting from prequestioning further processing of question-relevant information and/or criterion test practice, we did expect those using the combined format to outperform those using only prequestions. The last contrast allows us to compare the effects of criterion test practice with the effects of further relevant information processing.

Table 2 presents the t-values for these contrasts.

Table 2

Orthogonal Contrasts Relevant Learning

Contrast Number	Groups Compared		t-Value	Two tailed t-Probability (df = 120)
1	POST, PRE, PRE/POST(R), PRE/POST(P)	vs. CONTROL	2.27	.04
2	PRE, PRE/POST(R), PRE/POST(P)	vs. POST	-1.61	.12
3	PRE/POST(R), PRE/POST(P)	vs. PRE	- .59	_____
4	PRE/POST(P)	vs. PRE/POST(R)	- .44	_____

MS Error
Within Groups = 8.42

As can be seen from Table 2, the results of contrast 1 indicate that those given questions outperformed those without access to questions: providing students with questions did improve question-relevant retention. Although the retention test subscores suggested that those using only postquestions learned more than those using formats which included prequestions, the results of contrast 2 indicate that this difference is not statistically significant at the standard .05 level. As indicated by the results of the third contrast, the retention of those receiving postquestions along with prequestions was just about the same as those receiving only prequestions. Furthermore, as can be seen in the fourth comparison, there was no significant difference between the pre/post combinations. Since the third contrast suggests that the addition of postquestions to prequestions has little effect on relevant retention, it would seem to follow that it makes little difference on relevant retention whether the postquestions provide both criterion test practice and repetition or just criterion test practice.

With respect to incidental learning, our expectations concerning relative group performance are reflected in the following questions:

(1) How does the performance of students given question formats including prequestions compare with that of those given formats not including prequestions?

(2) How does the performance of students given only postquestions compare with that of those given no questions?

(3) Of those students given prequestions, how does the performance of those who receive postquestions referring to information incidental to the prequestions compare to that of those who do not?

(4) How do students given prequestions differ in performance from those given both prequestions and postquestions, where the postquestions refer again to the prequestioned information?

The contrast inferred in the first question allows us to assess whether prequestioning resulted in depressed incidental learning in comparison to those formats which did not include prequestioning. Based on the findings of other investigators, we expected prequestioning to focus study behavior to such an extent that incidental learning would be lowered. The comparison suggested in the second question between the group given only postquestions and the read-only control group attempts to uncover whether postquestioning had the 'indirect' effect of facilitating incidental retention. The third contrast allows us to assess whether, in a combined format, the use of postquestions which do not match prequestions facilitates incidental retention relative to the use of only prequestions or both prequestions and matching postquestions. This question, of course, has previously been answered in our observations about the retention subscores of Table 1; the PRE/POST(P) group did not do as well as did either the PRE or PRE/POST(R) groups on incidental retention. The last contrast addresses the expectation that the effect on incidental learning of inserting questions both before and after the text will be similar to the effect of prequestions alone.

Table 3 presents the t-values for these contrasts.

Table 3

Orthogonal Contrasts: Incidental Learning

Contrast Number	Groups Compared	t-Value	Two-tailed t-Probability (df = 120)
1	PRE, PRE/POST(R), PRE/POST(P) vs. POST, CONTROL	-2.43	.02
2	POST vs. CONTROL	.40	____
3	PRE, PRE/POST(R) vs. PRE/POST(P)	- .66	____
4	PRE vs. PRE/POST(R)	.65	____

MS error Within Groups = 7.99

The results of the first contrast confirm the expectation that prequestions depress incidental learning. The results of the second contrast indicate that students receiving only postquestions did about as well as the control students on incidental learning; there is no evidence that postquestions had the indirect effect of facilitating incidental retention above that associated with simply reading a passage. Since the PRE/POST(P) format did not result in facilitating incidental learning relative to the PRE or PRE/POST(R) format, there is no evidence that the PRE/POST(P) format induces a more generalized reading strategy than is produced by prequestions alone or prequestions with repeated postquestions. The results of the last contrast support the contention that the processing of incidental information induced by prequestions is little effected by the addition of matching postquestions.

Before proceeding to further analyses of the data, a summary of the major results disclosed thus far will be given. With respect to relevant retention, it was found that those given questions performed significantly better than did those not given questions. There was no evidence, though, that having access to questions both before and after text was superior to either using only prequestions or postquestions. In fact, trends in the relevant learning subscores

indicated that those given only postquestions outperformed those given formats including prequestions. Although this difference was not statistically significant it is in agreement with the finding of other investigators that the effect of postquestioning on relevant learning is stronger than that of prequestioning. With respect to incidental retention, it was found that prequestioning did depress incidental learning. On the other hand, there was no evidence that the POST format facilitated incidental learning relative to the CONTROL format.

Prequestions vs. Postquestions

More information about the question formats can be gained by considering just the groups CONTROL, POST, PRE and PRE/POST(R). Doing so allows one to conceive of the study as involving two factors, where presence of prequestions and absence of prequestions constitute the levels of one factor and presence of postquestions and absence of postquestions constitute the levels of the other factor. A two factor analysis of variance using these factors was performed for the dependent variables incidental learning and relevant learning. In this analysis the main effect of prequestions involves comparing the average effect of the PRE/POST(R) and PRE treatments with that of the POST and CONTROL treatments, while the main effect of postquestions involves comparing the average effect of the PRE/POST(R) and POST treatments with that of the PRE and CONTROL treatments.

The summary table for the analysis of variance using the dependent variable of incidental retention appears in Table 4. As can be seen, the only significant difference is the main effect of prequestions, reconfirming that formats including prequestions depress incidental learning relative to the no prequestioning formats.

Table 4

Analysis of Variance Summary Table:

Presence of Prequestions x Presence of Postquestions

Dependent Variable: Incidental Retention

Source of Variation	Sum of Squares	df	Mean Squares	F	Significance
PREQUESTIONS	30.25	1	30.25	4.02	.05
POSTQUESTIONS	.25	1	.25	.03	____
INTERACTION	4.41	1	4.41	.59	____
WITHIN CELLS	721.99	96	7.52		

The summary table for the two-factor analysis of variance conducted for the dependent variable of relevant retention appears as Table 5.

Table 5

Analysis of Variance Summary Table

Presence of Prequestions x Presence of Postquestions

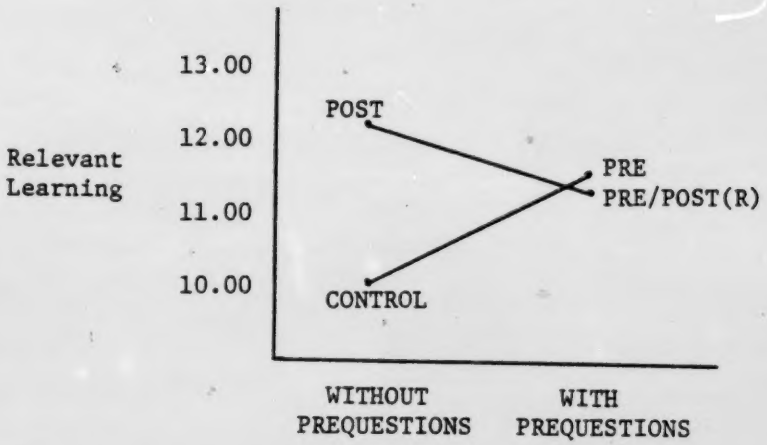
Dependent Variable: Relevant Retention

Source of Variation	Sum of Squares	df	Mean Squares	F	Significance
PREQUESTIONS	1.21	1	1.21	.15	____
POSTQUESTIONS	26.01	1	26.01	3.16	.08
INTERACTION	39.69	1	39.69	4.83	.03
WITHIN CELLS	789.19	96	8.22		

As can be seen from Table 5, a significant interaction was revealed by the analysis. The appearance of an interaction indicates that the two treatment means of one factor behave differently under different levels of the other factor. Based on the results reported previously, this interaction is expected; we have already observed that the addition of postquestions to a format which has no prequestioning results in facilitating relevant retention, while the addition of postquestions to a format which has prequestioning has little effect on relevant retention. Figure 1 graphically illustrates how the effects of the presence or absence of postquestions depend on the presence or absence of prequestions.

Figure 1

Interaction of Prequestions and Postquestions in Relevant Learning



Additional insight into the interaction is gained through tests of simple main effects. These tests are summarized in Table 6.

Table 6

Tests of Simple Main Effects
for Relevant Learning

Source	SS	df	MS	F	Significance
PREQUESTIONS (PRE)	1.21	1	1.21		
PRE vs. CONTROL	27.38	1	27.38	3.33	.10
POST vs. PRE/POST(R)	13.52	1	13.52	1.65	.25
POSTQUESTIONS (POST)	26.01	1	26.01		
POST vs. CONTROL	64.98	1	64.98	7.90	.01
PRE/POST(R) vs. PRE	.72	1	.72	.09	——
INTERACTION	39.69	1	39.69		
W. CELL	789.19	96	8.22		

As shown in Table 6, the difference between the POST and CONTROL groups is significant, while that between the PRE and CONTROL groups is not significant at commonly accepted levels. There was no significant difference in relevant retention between the PRE and PRE/POST(R) groups. Finally, the prequestion/postquestion combination was not significantly different from postquestions alone.

How is the lack of significance in the difference between the PRE and CONTROL means consistent with the finding presented earlier that questioning has a significant positive effect on relevant retention? You will recall that the conclusion presented earlier was based on a more powerful t-test which compared the effect of the CONTROL group to the average effect of all questioned groups, including the relatively higher scoring POST treatment. Hence it is certainly possible that the two tests might result in differing conclusions. While the ANOVA does not establish the superiority of the prequestioned groups relative to the CONTROL group, it does show that the POST format was reliably better than no questioning; this supports the contention that postquestioning has a stronger impact on relevant learning than does prequestioning.

Repeated Measures ANOVA: Question Format, Type of Learning, Level of Question

Still more information about the question formats was obtained through a 5 x 2 x 2 analysis of variance. The factors were (a) the five question formats, (b) the two types of learning (incidental vs. relevant), and (c) the two levels of questions (higher order v.s. lower order), with repeated measures on the last two factors. Table 7 contains a summary of this analysis.

Table 7

Analysis of Variance Summary Table

Question Format x Type of Learning x Level of Question

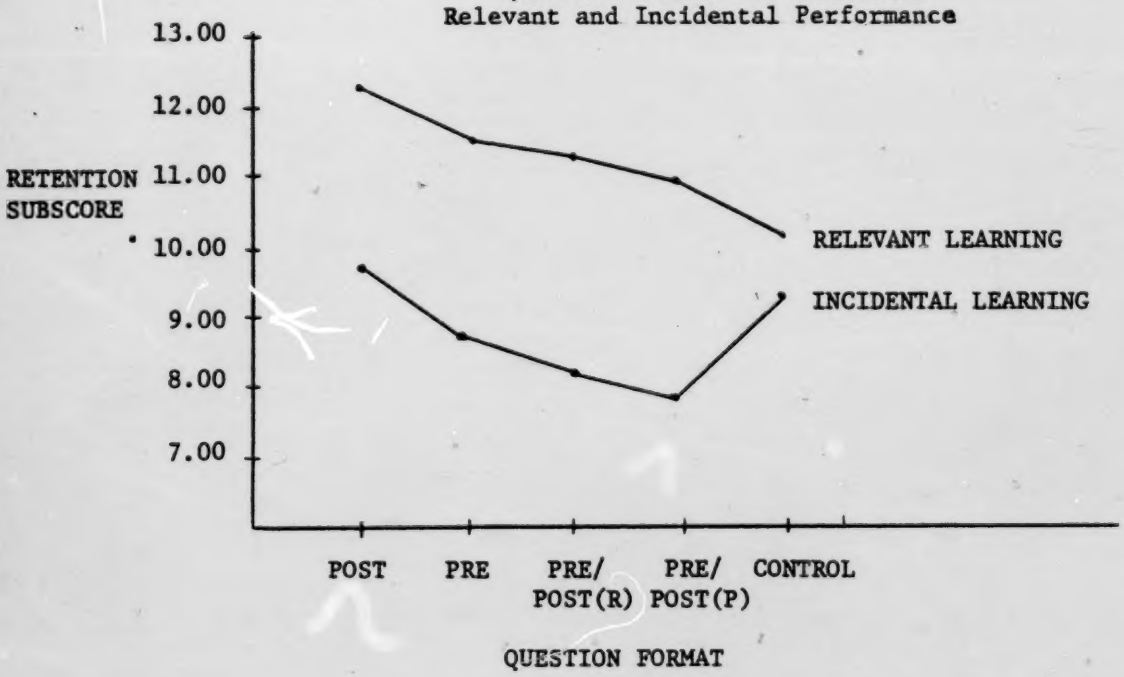
Source of Variation	Sum of Squares	df	Mean Squares	F	Significance
Question Format	37.29	4	9.32	1.39	____
Subj. W. Groups	802.44	120	6.69		
Type of Learning	193.44	1	193.44	127.46	.001
Type of Learning x Question Format	25.19	4	6.30	4.15	.005
Type of Learning x Subj. W. Groups	182.12	120	1.52		
Level of Question	82.42	1	82.42	51.60	.001
Level of Question x Question Format	7.65	4	1.91	1.20	____
Level of Question x Subj. W. Groups	191.68	120	1.60		
Type of Learning x Level of Question	10.66	1	10.66	6.49	.025
Type of Learning x Level of Question x Question Format	3.13	4	.78	.48	____
Type of Learning x Level of Question x Subj. W. Groups	196.96	120	1.64		

As the table indicates, there was no reliable difference between the treatments in total retention. Relevant learning was significantly greater than incidental learning; performance on the lower order questions was significantly higher than performance on the higher order questions. The other two significant findings were the interactions: (1) type of learning x question format and (2) type of learning x level of question. We will further explore both of these interactions.

An understanding of the first interaction is aided by the following plot of the relevant retention and incidental retention subscores for the various question formats.

Figure 2

Question Format and Retention:
Relevant and Incidental Performance



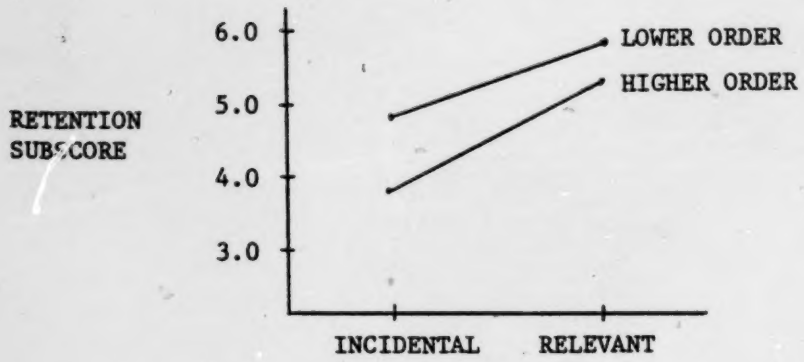
As shown in Figure 2, there is a notable difference in relevant and incidental learning throughout the first four formats, but not in the fifth, the CONTROL format. This is consistent with our expectations since the distinction between relevant and incidental learning does not really apply in the control group. In fact, tests of simple main effects indicated that relevant learning was significantly higher than incidental learning at the .001 level for all groups except the CONTROL. There was no significant difference between relevant and incidental learning in the control group ($p \leq .25$).

Tests of simple main effects were also performed to assess whether there were differences among the incidental retention means or differences among the relevant retention means. Neither test was significant at the .05 level, although the test comparing the relevant retention means approached significance ($p \leq .08$).

We turn now to the significant type of learning x level of question interaction. Tests of simple main effects revealed that relevant retention was greater than incidental retention for both higher and lower learning ($p \leq .001$); tests of simple main effects also indicated that lower order learning was greater than higher order learning for both incidental and relevant retention ($p \leq .005$). The interaction detected was due to the fact that the increment in performance for the relevant higher order items relative to the incidental higher order items was greater than that associated with the lower order items (Figure 3). One possible interpretation of this is that higher order learning is aided more by the use of questions than is lower order learning. But competing with this interpretation are two less interesting explanations.

Figure 3

Type of Learning and Retention:
Higher-order and Lower-order Performance



If the difference in difficulty between the items assigned to measure relevant higher order learning and those assigned to measure incidental higher order learning was greater than the difference in difficulty between the relevant and incidental lower order item sets, an interaction of the type represented in Figure 3 might be expected. As item assignment was random, there is no a priori reason for believing that this was in fact the case. But a look at the control group's subscores (Table 1) will provide more concrete information about the differences in difficulty between the item subsets.

In the control group the relevant items were in no way distinguished from the incidental items: hence, for this group, the overall difficulty of items measuring relevant learning should match the overall difficulty of the items measuring incidental learning. Table 1 indicates that the subscore for those lower order items measuring relevant learning was equal to the subscore for those lower order items measuring incidental learning. But the corresponding higher order subscores were not equal. A t-test was performed to test the hypothesis that the higher order item subsets were in fact equal in difficulty. The hypothesis could not be rejected at the .05 level. Hence differential item difficulty does not appear to be a tenable explanation for the interaction.

Another possible reason for the observed interaction is the tendency of subjects to perform near ceiling on the relevant items. Both higher and lower order relevant means are artifically depressed by the ceiling effect. Furthermore, since lower order items are easier than higher order items, the lower order mean is more sensitive to the effect than is the higher order mean. This difference in sensitivity may account for all, or at least part, of the difference in increments between the levels of questions across types of learning.

The major results brought to light by the above analyses of variance will now be summarized. Of the relevant learning means, only those of the POST and CONTROL groups were reliably different. The significant difference between the POST and CONTROL means was established through a direct comparison of the two treatments while exploring for simple main effects (Table 6). A test comparing all 5 relevant learning treatment means was performed as an offshoot of the Question Format x Type of Learning x Level of Question ANOVA. This test indicated that there were no significant differences between any of the treatment means. Since the test comparing all 5 means was less powerful than the test comparing the POST and CONTROL groups directly, it is not inconsistint that the former test does not reestablish the results of the latter.

In comparison to students not having access to the prequestions, those who did experienced depressed incidental learning. This finding was supported earlier in an orthogonal contrast (Table 3) and again in the significant main effect of the Prequestions x Postquestions ANOVA presented in Table 4. But the comparison of incidental learning means done in conjunction with the Question Format x Type of Learning x Level of Question ANOVA detected no reliable differences between the means. Again the results of the three tests can be considered consistent since the orthogonal contrast and the two factor ANOVA provided more powerful comparisons of those receiving prequestions and those not receiving prequestions.

The Question Format x Type of Learning x Level of Question ANOVA detected no reliable differences in the overall learning means of the 5 treatments. Furthermore, this analysis indicated that lower order learning was greater than higher order learning for all groups, and relevant learning was greater than incidental learning for all groups except the CONTROL. A Type of Learning x Level of Question interaction was supported by the analysis. One possible explanation of the interaction is that higher order learning benefited more by the insertion of questions than did lower order learning.

Data collected on the time students spent studying the materials is summarized in Table 8.[1]

Table 8

Mean Time Spent Inspecting Different Parts of the Materials

Format	n[a]	Pre-questions		Post-questions		Passages		Total	
		M	SD	M	SD	M	SD	M	SD
CONTROL	22	---	--	---	--	36.45	10.72	36.45	10.72
PRE	22	13.42	4.04	---	--	40.75	11.16	54.17	14.51
POST	21	---	--	19.34	4.92	38.46	8.25	57.80	11.20
PRE/POST(R)	21	11.22	3.88	19.98	7.15	37.91	9.68	69.11	16.04
PRE/POST(P)	23	9.34	3.63	18.62	4.60	34.50	10.40	62.46	14.97

Note. Mean scores are in minutes.

[a]Number of subjects within each treatment for which complete time records were available. All means within a treatment are based on the subjects with complete records.

[1]When a computer failure occurred while a student was studying the materials, the time history collected to that point was lost. The proctor reentered the student into the program at that point in the materials where he had been prior to the failure. Hence complete records were not available for all students.

For each set of means, a one-way analysis of variance was used to assess their differences. When a significant difference was detected, mean comparisons were performed using the Tukey-B test (Winer, 1972).

There were no significant differences in the postquestion means of the POST, PRE/POST(R), and PRE/POST(P) groups, or the passage means of the five groups. There was a significant difference in the time the PRE, PRE/POST(R) and PRE/POST(P) groups spent on the prequestions ($p \leq .01$). At the .05 level, the PRE mean was significantly greater than the PRE/POST(P) mean, while the PRE/POST(R) mean was not reliably different from either of the other two means. There was also a significant difference in the total time the five groups took to complete the materials ($p \leq .001$). At the .05 level, the CONTROL mean was significantly smaller than the other means, while the PRE/POST(R) mean was significantly greater than the POST and PRE means. No reliable differences could be detected between the PRE/POST(R) and PRE/POST(P) total time means, or between the PRE, POST, and PRE/POST(P) total time means.

The results concerning the time groups spent studying the different parts of the materials allow us to reject one possible explanation for why we did not replicate the finding of Boyd (1973) that the combination of pre- and postquestioning results in superior relevant retention relative to either format alone. As the time data indicates, those in the PRE/POST(R) group spent about the same amount of time on the prequestions and passages as did those in the PRE group; they spent about the same amount of time on the postquestions and passages as did those in the POST group. Furthermore, the PRE/POST(R) group spent significantly more time on the task than did either the PRE group or the POST group. Based on study time alone, one might expect the relevant learning of the PRE/POST(R) group to have been stronger than that of the PRE or POST groups. But it was not, and it is to speculations about why it was not that we now turn.

Discussion of Relevant Retention and Inserted Questions

Since the PRE group did as well as the PRE/POST(R) group on relevant retention, we may assume that the additional processing provided by postquestioning had little effect on relevant learning. Why Boyd was able to see an effect while we were not may be due to the difference between the studies in how students were allowed to use prequestions. In our study, those using prequestions could review them while they studied the text. In Boyd's study students were not allowed to review prequestions once they began the text. Because of their free access to prequestions, it is likely that those in our prequestioned groups were better able to formulate answers to the prequestions while they studied the text than were those in Boyd's study. It may be that the impact of postquestions in a combined format depends on how well students have been able to formulate answers to prequestions prior to seeing the postquestions. Free access to prequestions may result in learning the question relevant material so well that the additional processing resulting from answering the questions again adds little to learning.

At the onset of our study, we did expect the PRE/POST(R) format to result in superior relevant retention relative to the PRE format. But we were less certain about how the PRE/POST(R) format would compare to the POST format. The textual processing associated with post-questioning typically results in more relevant learning than does that associated with prequestioning. Since the processing induced by the PRE/POST(R) format is just an extension of that induced by prequestions, it is difficult to speculate which format will result in superior relevant retention. The addition of postquestions to prequestions in Boyd's study appears to have compensated for the less effective learning resulting from prequestioning: those using the combined format outperformed those using only postquestions. Our results, of course, indicate that the two formats were not significantly different in the relevant learning they promoted. Why we did not replicate Boyd's finding may be due to differences in the stimulus materials used in the two investigations.

As was discussed in the review of research, Rickards (1976) has observed that the formulation of answers to inserted questions may require less reliance on memory when the inserted questions appear as prequestions rather than as postquestions. If the stimulus materials create a situation in which this advantage results in the prequestion group answering more of the inserted questions correctly, those using prequestions may learn more relevant information than do those using only postquestions. Assuming those using prequestions do answer more inserted questions correctly than do those using postquestions, if review of the prequestions is restricted, those using a combined format will be even more likely to outperform those using only postquestions.

Boyd's materials did result in those using combined formats more successfully answering the inserted questions. Evidence for this is provided by comparing scores on inserted postquestions for those using the combined formats with scores on inserted postquestions for those using only postquestions. In Boyd's study, those using both pre- and postquestions scored significantly higher on the inserted postquestions than did those using only postquestions.

In our investigation, how the PRE/POST(R) and POST groups compared on the performance of inserted questions is summarized in Table 9. Listed are the means for the following item subsets:

(1) higher order postquestions <u>not</u> repeated on the retention test,

(2) lower order postquestions <u>not</u> repeated on the retention test,

(3) higher order postquestions repeated on the retention test, and

(4) lower order postquestions repeated on the retention test.

t-test indicated that there were no significant differences between the groups on any of the four subscore means. Apparently, the advantage prequestions may have relative to postquestions in placing less demand on students' memory did not play a significant role in the stimulus materials of this investigation.[2]

Table 9

POST and PRE/POST(R) Inserted Question Means as a Function of Appearance of Inserted Questions on the Retention Test, and Retention Means of Repeated Items

Item Subset	POST				PRE/POST(R)			
	Inserted Questions		Retention		Inserted Questions		Retention	
	M	SD	M	SD	M	SD	M	SD
Higher-Order Items								
Repeated	5.65	1.23	6.17	1.23	5.65	1.87	5.35	2.12
Not Repeated	4.52	1.47	--	--	4.48	1.76	--	--
Lower-Order Items								
Repeated	6.17	1.19	6.39	.94	5.96	1.69	6.00	1.70
Not Repeated	5.91	1.41	--	--	6.48	1.31	--	--

Note. All data is based on the 23 subjects in each group for which inserted question data were available.

Speculations concerning the retention of relevant information experienced by students receiving only prequestions, only postquestions, or the combination of prequestions and postquestions will now be summarized. It seems that if students are allowed to review prequestions while they are studying the materials, the addition of postquestions to the treatment will not improve relevant retention. If this review is not allowed, the further processing of question-relevant information provided by postquestions may improve relevant retention. The addition of prequestions to a postquestion format will typically not improve relevant retention. Materials which place great demands on student memory may provide an exception to this generalization. Such demands may be made, for example, by passages which are laden with factual information and inserted questions requiring retrieval of selected facts. Rickards (1976) provides a concrete example of such stimulus materials. If the materials do make demands on students' memory,

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[2]The question arises as to whether the relative advantage of prequestions is a function of whether postquestions require recall, as in Boyd's study, or recognition, as in our investigation. Since we did not compare the two postquestion types, we have no data upon which to base an answer to this question.

the combined format may be superior to only postquestioning but may not be superior to only prequestioning. As we have observed before, if students are allowed to review prequestions while they study the text, additional postquestioning may add little to relevant retention.

Textual Processing

At several points in our discussion we have used the conjecture that the relevant information processing resulting from postquestioning may differ from that induced by prequestions. Some evidence supporting this conjecture is provided by comparing the following scores within the POST and PRE/POST(R) groups: scores on those inserted postquestions which were also retention test items and scores on those same questions when they appeared as retention items (Table 9).

For the 23 students in the PRE/POST(R) group with complete records on responses to postquestions, the mean score on the retention test for higher order items used as postquestions was 5.35. For these students the mean score on the retention test for those lower order items used as postquestions was 6.00. Two-tailed t-tests indicated that neither subscore was significantly different from its inserted question counterpart, although the difference in the higher order subscores approached significance ($p \leq .09$).

For the 23 students in the POST group with complete records on responses to postquestions, the mean score on the retention test for those higher order items used as inserted questions was 6.17. For these students, the mean score on the retention test for those lower order items used as inserted questions was 6.39. While the difference in the lower order item subscores was not significant, the higher order subscores were significantly different at the .002 level.

While no significant changes seemed to occur in the PRE/POST(R) group between the two question answering periods, the POST group seemed to make gains in relevant higher order learning. If the two groups had processed the question relevant information in the same way, one would expect the changes between the two question answering periods to be similar. Since they are not, some support is provided for the alternative hypothesis.

CONCLUSIONS

Some conclusions regarding the question formats used in the study will now be drawn. The combined format of prequestioning and postquestioning, with the postquestions repeating the prequestions, is, in general, an inefficient way to promote relevant learning. In our study it resulted in an approximately 20% increase in student study time relative to the use of only pre- or postquestioning but did not result in improved relevant retention relative to these formats.

The combined format of prequestioning and postquestioning, with the postquestions containing new items, is ineffectual. The appearance of prequestion-incidental postquestions does not seem to induce more regard for incidental information than results in groups using only prequestions or prequestions and matching postquestions. Furthermore, as indicated by the group's spending significantly less time with the prequestions than did the other prequestioned groups, the new postquestions seem to induce less regard for the learning of relevant information.

Time spent studying the materials with the use of only postquestions was not significantly different from time spent with the use of only prequestions. Also there were no significant differences in the relevant learning promoted by the two formats. Yet postquestioning may be preferable to prequestioning for two reasons:

(1) Postquestioning typically has a stronger positive impact on higher order relevant learning than does prequestioning

and

(2) Prequestioning depresses incidental learning relative to postquestioning.

As the analysis of time spent studying the textual materials indicated, those using only prequestions, only postquestions, or no questions at all did not differ reliably in the time they took to study the passages. But those who studied with no questions did take considerably less study time than the others when time spent on inserted questions was added to passage time. The learning advantages resulting from inserted questions must be weighed against the extra time involved in their use.

The increments we observed in relevant learning which resulted from inserted questions are not large.[3] Relative to the control group, relevant retention increased about 12% in those groups using only prequestions or postquestions. Yet the use of prequestions or postquestions increased the time taken to complete the materials by approximately 50%. Was this a worthwhile investment of students' time?

With different textual materials and different types of questions the above figures would undoubtably change, but the above question would still be relevant. The instructor who contemplates the use of questions should assess how difficult it is for the learner to recognize what it is he is suppose to retain from the materials and how critical it would be to instructional continuity if certain things from the passage were not retained. Such considerations will help the instructor decide whether a, perhaps slight, increase in the probability of relevant learning is worth the increased study time.

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[3]The increments observed are typical of those commonly found by investigators. In those studies reviewed by Anderson and Biddle (1975) which compared postquestioning to no questioning, the mean % increment in relevant learning for the postquestioned groups was 13.2. The percent increment in the present study for POST was 14.3. In those studies reviewed which compared prequestioning to no prequestioning, the mean % increment in relevant learning for the prequestioned groups was 10.8. The percent increment in the present study for PRE was 9.3.

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APPENDIX

Student Directions

The study you will be a part of concerns methods to help students in learning from written materials presented on a computer display. The particular method we are interested in is the use of questions related to the materials.

You will be asked to read eight passages presented on a computer terminal. Before each passage you will be given four questions requesting information which is either contained in or can be inferred from the passage. (From now on these questions will be called prequestions.) The prequestions are open-ended. They are designed to direct your learning as you read the passage. If after studying the passage you feel reasonably confident about your answers to prequestions, then you have a sign that you have studied the passage adequately.

When you have completed reading all eight passages and working through their prequestions, you will be asked to take a final test. The test will contain the prequestions you have seen, but now they will be restated in multiple-choice format. The test will measure how much you remember from the information you were directed to learn from the prequestions. It will also conclude the study.

You will not be allowed to take any notes while you are reading through the materials.

The passages are about 400 words each. Each concerns different and unrelated topical areas. Topics chosen are from the humanities, social sciences, physical sciences, and biological sciences.

(As you read through the rest of the directions, you may wish to refer to the Key Board Directions summarized on the next page.)

Passage prequestions will be displayed on the terminal before you see their related passage. After reading and familiarizing yourself with these prequestions, you can go on to the passage by pressing the 'NEXT' key on the computer terminal keyboard. Thereafter, anytime you wish to review the prequestions again, press 'HELP' and they will be displayed again. A press of the 'NEXT' key will return you to the passage.

Some passages are contained on two pages (two separate computer displays). You will always begin on page one. If the passage continues on the next page, this will be indicated at the bottom of the first page. The second page of a two-page passage will be displayed when you press the 'NEXT' key. If you wish to return to the first page from the second you may do so by pressing the 'BACK' key.

While you are reading through a passage you may review its prequestions (by pressing 'HELP') and switch between its pages (by pressing 'NEXT' or 'BACK') as many times as you wish.

After you have completed the passage and feel like you can answer the prequestions, you may indicate this by pressing the 'f' (for finished) key. You cannot go back to review the previous prequestions or passage after you have pressed the 'f' key, so do not press it before you feel you are ready to do so.

After you press the 'f' key, the prequestions for the next passage will be displayed and you will begin the procedure again. When you have completed the last passage and press the 'f' key, you will be asked to take the final test. Remember that this test will contain the prequestions you have seen with each passage stated in multiple choice form. The final test will be given in paper and pencil format. The proctor will give you a copy of the test.

If you have any questions please direct them to the proctor. You can take as much time as you need to read through the passages. When you are ready to begin the passage readings press the 'NEXT' key.

Key Board Directions

To get from PREQUESTIONS to PASSAGE press NEXT

To get from PASSAGE to PREQUESTIONS press HELP

To get from PAGE 1 of a PASSAGE to PAGE 2 press NEXT

To get from PAGE 2 of a PASSAGE to PAGE 1 press BACK

To get from PASSAGE to PREQUESTIONS of NEXT PASSAGE press f

Student Directions

The study you will be a part of concerns methods to help students in learning from written materials presented on a computer display. The particular method we are interested in is the use of questions related to the materials.

You will be asked to read eight passages presented on a computer terminal. Both before and after each passage you will be given four questions. These questions request information which is either contained in or can be inferred from the passage. (From now on the questions preceding a passage will be called prequestions and those following a passage will be called postquestions.) The prequestions are open-ended. They are designed to direct your learning as you read the passage. The postquestions, on the other hand, are in multiple choice format. They are designed to serve as check points on how well you are learning the materials. If you feel reasonably confident about your answers to both pre- and postquestions, then you have a sign that you have studied a passage adequately.

There is a connection between the pre- and postquestions. Two of the postquestions are merely restatements of two of the prequestions in multiple choice format. The other two postquestions are not the same as the prequestions.

When you have completed reading all eight passages and working through the pre- and postquestions, you will be asked to take a final test. The test will contain both multiple choice postquestions you have seen as well as multiple choice restatements of the passage prequestions you did not receive as postquestions. It will measure how much you remember from the information you were directed to learn (from both the pre- and postquestions). It will also conclude the study.

You will not be allowed to take any notes while you are reading through the materials.

The passages are about 400 words each. Each concerns different and unrelated topical areas. Topics chosen are from the humanities, social sciences, physical sciences, and biological sciences.

(As you read through the rest of the directions, you may wish to refer to the Key Board Directions summarized on the next page.)

Passage prequestions will be displayed on the terminal before you see their related passage. After reading and familiarizing yourself with these prequestions, you can go on to the passage by pressing the 'NEXT' key on the computer terminal keyboard. Thereafter, anytime you wish to review the prequestions again, press 'HELP' and they will be displayed again. A press of the 'NEXT' key will return you to the passage.

Some passages are contained on two pages (two separate computer displays). You will always begin on page one. If the passage continues on the next page, this will be indicated at the bottom of the first page. The second page of a two-page passage will be displayed when you press the 'NEXT' key.

If you wish to return to the first page from the second you may do so by pressing the 'BACK' key.

While you are reading through a passage you may review its prequestions (by pressing 'HELP') and switch between pages (by pressing 'NEXT' or 'BACK') as many times as you wish.

After you have completed the passage and feel like you can answer the prequestions, you may indicate this by pressing the 'f' (for finished) key. You cannot go back to review the prequestions or the passage after you have pressed the 'f' key, so do not press it before you feel you are ready to do so.

After you press the 'f' key the first postquestion will be displayed. Each postquestion will be displayed one at a time. Please indicate your answers to postquestions by pressing the letter (A,B,C,D or E) of the answer you believe is correct. The answer you choose will be written at the bottom of the screen. While the question is displayed, if you change your mind about an answer, just press the 'ERASE' key and then press your new answer.

When you have completed a postquestion a press of the 'NEXT' key will display the next one. You cannot return to a previously displayed postquestion. Also you cannot go on to the next postquestion without answering the one you are on. When you have completed the fourth postquestion a press of the 'NEXT' key will display the next set of prequestions and you will begin the procedure again.

When you press the 'NEXT' key after you have completed the last postquestion of the eighth passage you will be asked to take the final test. Remember that this test will contain both multiple choice postquestions you have seen as well as multiple choice restatements of the passage prequestions you did not receive as postquestions.

The final test will be given in paper and pencil format. The proctor will give you a copy of the test.

If you have any questions please direct them to the proctor. You can take as much time as you need to read through the passages. When you are ready to begin the passage readings press the 'NEXT' key of the terminal keyboard.

Key Board Directions

To get from PREQUESTIONS to PASSAGE press NEXT

To get from PASSAGE to PREQUESTIONS press HELP

To get from PAGE 1 of a PASSAGE to PAGE 2 press NEXT

To get from PAGE 2 of a PASSAGE to PAGE 1 press BACK

To get from PASSAGE to POSTQUESTIONS press f

To get from POSTQUESTION to POSTQUESTION press NEXT

To get from fourth POSTQUESTION to PREQUESTIONS OF NEXT PASSAGE press NEXT

When answering POSTQUESTIONS, to change an answer first press ERASE and then press the new answer (A,B,C,D or E)